

REMARKS

Responsive to the outstanding Office Action, applicant has carefully studied the Examiner's rejections and the comments relative thereto. Favorable reconsideration of the application is respectfully requested in light of the amendments and following detailed arguments.

In the amendment, claims 18, 22, 23, 25, 27-29, 31, 33 and 34 were amended, and claims 35-37 were newly presented. It is submitted that no new matter has been entered into the claims through these amendments. Newly presented claims 35-37 include subject matter removed from other claims for clarity purposes.

REJECTIONS UNDER 35 USC §112, second paragraph

The Examiner rejected claims 18-34 for an extensive list of objections under 35 USC 112 second paragraph. Applicants respond as follows.

With respect to paragraph A), the term "branched graft polyamide" is used as keyword and a definition of what is to be understood is given immediately afterwards by features b1) and b2). It is believed that this description adequately defines the term as used in the application and therefore renders the rejection moot.

With regards to paragraphs B,C) "polyamine acid chains" contains a spelling mistake and has been correctly rewritten as "polyamino acid chains". This term is defined in EP 0 409 115, which explicitly is made reference to. Further, a detailed experimental procedure on how these polyamides are synthesized is disclosed on p. 15 of the specification. Here it clearly is stated, that the oligomeric styrene maleinic acid anhydride copolymer, which corresponds to the basic structure (formula 1) of the later branched graft polyamide, possesses a number average molecular weight (Mn) of approx 1000 g/mol. It is believed that this clarifies the subject matter being claimed and that this therefore complies with the requirements of section 112.

With regard to paragraph D), it is respectfully pointed out that for the parts as stated for the components A and B "parts by weight" is clearly disclosed in claim 18, and as such this rejection is moot..

With regard to paragraph E), the claims have been amended in such a manner as to have new dependent claims in which the optional matter (parts of isophthalic or terephthalic acid, respectively, being replaced by the named other acids) is disclosed. Therefore the noted claims no longer contain the improper language.

With regard to paragraph F) Claim 23 further specifies and limits of the scope of feature b) of claim 18. Both features b.1) and b.2) of claim 18 demand the incorporation of polyamides, which in feature b.1) are referred to as "polyamino acid chains" being grafted on the SMA basic structure or represent in feature b.2) the product derived from the hydrolytic polymerisation of amino acids and/or lactams. The feature, that at least three arms are present is to be understood, that in case of feature b.1) at least three polyamino acid chains are attached to the SMA structure, whereas in feature b.2) the product resulting from the polymerisation contains at least three branched arms which result from the added components with a branching effect.

To clarify this point, claim 23 has been amended to recite "... wherein the graft polyamides have more than three arms and the polyamino acid chains of b.1) and/or the basic building block of b.2) represent a polyamide selected from the group comprising PA6 ...". It is therefore believed that this has been clarified and complies with section 112.

With respect to paragraph G) Claim 24 clearly recites the graft polyamides b) having a defined relative and melt viscosity. Both values explicitly make reference to compound b). It is therefore believed that claim 24 is clear and in compliance with section 112.

With respect to paragraph H), Claim 26 defines that the PDI of compound b) corresponds to the PDI of compound a). Since no hint is given, that any absolute M_n or M_w values of both compounds are to be maintained, the only criterion is the molecular weight distribution. The claim language gives a precise teaching on how both compounds a) and b) have to be conditioned and is therefore believed to be clear.

With respect to paragraph I), the claim in question has been amended to recite "... PA6I/6T, PAMXDI/MXDT/6I/ 6T or mixtures ..." which is believed to clarify the subject matter claimed.

With respect to paragraph J), the abbreviations used therein are internationally established standard abbreviations for polyamides, which for example are defined in the international norm DIN ISO 1874-1 and the "Nylon Plastics Handbook" by M.I. Kohan. Excerpts from this work are enclosed as attachment A. It is believed that in light of this disclosure of the standard nomenclature, that these abbreviations are clear.

With respect to K) claim 29 has been amended in a manner believed to establish proper Markush language.

With respect to L) this language has been clarified.

With respect to M), GIT stands for "gas injection technology" and WIT means "water injection technology. A disclosure relative to these two standard techniques is given on page 11, line 25 of the specification, where the procedures referred to as GIT or WIT are explained. It is therefore believed that amending the claims to include these terms is proper as one skilled in the art would recognize the technology disclosed therein.

With regard to N), "inherent" has been deleted.

With regard to O), claim 31 has been amended to depend from claim 18.

In view of the above it is respectfully submitted that the Examiner's rejections have been addressed and that these claims are allowable over the provisions of USC 112, second paragraph. Reconsideration and withdrawal of the rejections thereagainst are respectfully requested.

REJECTIONS UNDER 35 USC §112, first paragraph

It is believed that this rejections is overcome by correcting the wording to "polyamino" as discussed above.

However, it is also noted that it is completely impractical to disclose every possible permutation of a class of compounds, especially if the compounds being referred to - polyamides - are a well known class of polymers. The incorporation by reference that the Examiner refers to is not relevant in light of the foregoing.

REJECTION UNDER 35 USC §102

Claim 33 was rejected under 35 USC 102 as being anticipated by US 6,211,266 to Weber. Claim 33 has been amended herein to properly refer to the use of the polyamide material according to claim 18. It is therefore believed that claim 33 now defines over Weber alone. Reconsideration and withdrawal of this rejection is therefore respectfully requested.

REJECTIONS UNDER 35 USC §103

The Examiner states that it would have been obvious for the person skilled in the art to combine US '266 (Weber) with the two Schmid documents (EP '648 and '115) thus arriving at the claimed subject matter of the present application. The Examiner argues that component C of the US '266 would correspond to the component A)b)1 of the present independent claim, whereas component B of US '266 would correspond to component A)b)2. Further, he states that compound A also would encompass amorphous polyamides as claimed by feature A)c) of claim 18.

Applicant respectfully disagrees with this opinion for the reasons that follow.

a) Comparison of component C (US '266) with component A)b)1

Nothing in the disclosure of US '266 provides and teaching or suggestion that the component C represents "branched grafted polyamides" as required by feature A)b)1 of present claim 18. This becomes obvious if one looks at the production-procedure of PA6v, which represents component A)b)1 in present application (page 15, last paragraph of the specification). Here, the acid anhydride groups of the SMA backbone are reacted with ε-caprolactam, which forms polyamino acid chains being grafted onto the maleinimide units. Moreover, if one takes into consideration the proportions of the starting materials used therein, it becomes clear that the predominant part of this PA6v is composed of the polyamino acid chains derived from ε-caprolactam, since about 40 kg of caprolactam versus only 1.7 kg of SMA are employed. From this, it is evident, that the resulting branched grafted polymer cannot be described in any other way as a branched polyamide. Also the name "PA6v" further suggest this fact.

In contrast, US '266 does not teach to graft polyamino acids on these maleinimides (compound C3, see col. 3, line 61 to col. 4, line 9, which are optional). The only examples of the maleinimide represent alkyl- or cycloalkyl-maleinimides, contrary to the disclosure of the present invention.

Even more importantly, US '266 describes as mandatory compound C2 for component C "at least one unsaturated nitrile" which is incorporated "from 5 to 40 % per weight" (see col. 3, lines 57 to 60). However, no nitriles are present in the feature A)b)1 of claim 18.

In summary of this point, component C consists of a copolymer, which is derived from styrene or its derivatives, unsaturated nitriles and optionally further unsaturated monomers e.g. maleinimides. Therefore, it becomes obvious that in any case the component C can be addressed as polyolefinic copolymer. These components of the applied reference do not have anything in common with the branched polyamides, which are used as compound A)b) according to present invention. Thus, the person skilled in the art cannot draw any motivation from US '266 to combine its teaching with EP '115, because different compounds are addressed.

b) Comparison of component A (US '266) with component A)a and c)

Claim 18 of the present application teaches a polyamide mixture (i.e. a blend, see wording of claim 1 A)) of the compounds A)a) to d) and therefore a blend of two different polyamides, namely a semicrystalline linear polyamide disclosed in A)a) and a amorphous polyamide disclosed in A) c).

The Examiner opines that all polymers have some amorphous character and therefore wrongly equates component A of US '266 with the blend of polyamides A)a and c) of present application. However, compound A of US '266 clearly is addressed as "partly crystalline thermoplastic polyamide" (col. 2, line 16), which can be prepared by the monomers named below (col. 2, lines 29-57). In fact, US '266 also uses polyamide blends (col. 2, lines 58-63), yet with the proviso, that "two or more of the monomers mentioned above" are copolymerized. In such it becomes clear, that here a blend of two partly crystalline polyamides is addressed, i.e. a blend of two polyamides from the

same category. US '266 fails to disclose a polyamide blend as claimed in claim 18 of the present application.

One skilled in the art is aware of the fact that a blend of semi crystalline and amorphous polyamides as claimed by features A)a) and c) of claim 18 of the present invention significantly differs in its physical properties e.g. rheologic and mechanical properties and/or melting point from semicrystalline polyamides, their blends or copolyamides derived from the same monomers as the blend components, also if the monomer amounts are identical. Therefore, it is submitted that this material does not correspond to the claimed element of the present invention as alleged by the Examiner.

c) Comparison of component B (US '266) with component A)b)2

Compound B of US '266 represents a copolyamide which is derived from on the one hand E-caprolactam and on the other hand dicarboxylic acids and diamines (col. 3, lines 4-15). Therefore, it becomes obvious that the copolyamides used therein are linear and unbranched, respectively.

However the feature A)b)2 of claim 18 demands the usage of an combination of branching agents which have the composition of an polymer of an at least di- and tri-functional monomer, respectively, comprising an amine or a carboxylic acid. These trifunctional compounds essentially differ from the di-functional agents, namely the diamines and/or dicarboxylic acids as stated for compound B of US '266. Therefore, it becomes clear that the copolyamides described under A)b)2 also are branched copolymers, of course, an in such differ from compound B of US '266.

Moreover, US '266 does not give any hint for the person skilled in the art to use branched copolyamides for the compound B, let alone branched copolyamides derived from the reaction of adequate monomers with a combination of two different branching agents. In such one skilled in the art again is given no motivation to combine the teaching of US '266 with EP '348.

d) Summary

As stated above one skilled in the art would not consider combining US '266 with anyone of EP '115 and EP '648 for the given reasons.

Moreover, no reasonable combination of the applied references lead to the matter of present invention. Any reasonable combination of these references at least lack the disclosure of the blend of a semicrystalline and a amorphous polyamide (features A)a) and A)c)). Furthermore, the present application does not have a nitrilic component incorporated into the backbone given by formula 1.

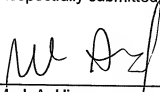
Applicant submits that the primary reference, US '266 discloses totally different polyamides, which cannot be compared to the matter of present application. As such, claim 18, and the claims dependent therefrom, are believed to distinguish over the applied art of record.

SUMMARY

In view of the forgoing, independent claim 18 is believed to be allowable over the applied art of record, and action towards that end is respectfully requested. Claims 19-37, which depend directly or indirectly from independent claim 18 are believed to be allowable based, at least, upon this dependence.

Should the Examiner wish to modify the application in any way, applicant's attorney suggests a telephone interview in order to expedite the prosecution of the application.

Respectfully submitted,



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INTERNATIONAL STANDARD

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Plastics — Polyamide (PA) moulding and extrusion materials —

Part 1: Designation

*Plastiques. — Matériaux polyamides (PA) pour moulage et extrusion —
Partie 1: Désignation*



Reference number
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LEGAL

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 1874-1 was prepared by Technical Committee ISO/TC 61, *Plastics*, Sub-Committee SC 9, *Thermoplastic materials*.

This second edition cancels and replaces the first edition (ISO 1874-1:1985), the scope of which has been extended to include not only homopolymers but also copolymers.

ISO 1874 consists of the following parts, under the general title *Plastics — Polyamide (PA) moulding and extrusion materials*:

- *Part 1: Designation*
- *Part 2: Preparation of test specimens and determination of properties*

Annex A forms an integral part of this part of ISO 1874.

Plastics — Polyamide (PA) moulding and extrusion materials —

Part 1: Designation

1 Scope

1.1 This part of ISO 1874 establishes a system of designation for polyamide (PA) thermoplastic materials, which may be used as the basis for specifications.

It covers polyamide homopolymers for moulding and extrusion based on PA 6, PA 66, PA 69, PA 610, PA 612, PA 11, PA 12, PA MXD6, PA 46, PA 1212 and copolyamides of various compositions for moulding and extrusion.

1.2 The types of polyamide plastic are differentiated from each other by a classification system based on appropriate levels of the designatory properties

- a) viscosity number,
- b) tensile modulus of elasticity and
- c) presence of nucleating agent,

and on information about chemical structure, intended application, method of processing, important properties, additives, colour, fillers and reinforcing materials.

1.3 The designation system is applicable to all polyamide homopolymers and copolymers. It applies to materials ready for normal use, unmodified and modified by colorants, additives, fillers, reinforcing materials, polymer modifiers, etc.

This part of ISO 1874 does not apply to monomer casting-type polyamides of PA 6 and PA 12.

1.4 It is not intended to imply that materials having the same designation give necessarily the same performance. This part of ISO 1874 does not provide engineering data, performance data or data on processing conditions which may be required to specify a material for a particular application and/or method of processing.

If such additional properties are required, they shall be determined in accordance with the test methods specified in part 2 of ISO 1874, if suitable.

1.5 In order to specify a thermoplastic material for a particular application or reproducible processing, additional requirements may be given in Data Block 5 (see clause 3).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 1874. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 1874 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 307:1984, *Plastics — Polyamides — Determination of viscosity number.*

ISO/R 527:1966, *Plastics — Determination of tensile properties.*

ISO 1043-1:1987, *Plastics — Symbols — Part 1: Basic polymers and their special characteristics.*

ISO 1043-2:1988, *Plastics — Symbols — Part 2: Fillers and reinforcing materials.*

ISO 1874-2:1987, *Plastics — Polyamide (PA) moulding and extrusion materials — Part 2: Preparation of test specimens and determination of properties.*

ISO 3451-4:1986, *Plastics — Determination of ash — Part 4: Polyamides.*

3 Designation system

The designation system for thermoplastics is based on the standardized pattern given in figure 1.

The designation consists of an optional Description Block, reading "Thermoplastics", and an Identity Block comprising the International Standard number and an Individual Item Block. For unambiguous designation, the Individual Item Block is subdivided into four data blocks comprising the following information:

- Data Block 1: Identification of the plastic by its symbol (PA), in accordance with ISO 1043-1, and information about chemical structure and composition (see 3.1).
- Data Block 2: Position 1: Intended application or method of processing (see 3.2).
Positions 2 to 8: Important properties, additives and supplementary information (see 3.2).
- Data Block 3: Designatory properties (see 3.3).
- Data Block 4: Fillers or reinforcing materials and their nominal content (see 3.4).

For the purpose of specifications, a fifth data block may be added containing additional information. The kind of information and the code-letters used are not the subject of this part of ISO 1874.

The first character of the Individual Item Block shall be a hyphen.

The four data blocks shall be separated from each other by a comma.

If a data block is not used, this shall be indicated by doubling the separation sign, i.e. by two commas (,,).

3.1 Data Block 1

In this data block, after the hyphen, the polyamide plastic is identified using the symbols and designations listed in tables 1 and 2.

Polyamides containing a plasticizer may be designated by adding the letter P after the symbol, separated from it by a hyphen (example: PA 610-P).

Polyamides containing an impact modifier may be designated by adding the letters HI after the symbol, separated from it by a hyphen (example: PA6-HI).

Designation						
Description Block (optional)	Identify Block					
	International Standard Block	Individual Item Block				
		Data Block 1	Data Block 2	Data Block 3	Data Block 4	Data Block 5

Figure 1 — Data block designation system

Table 1 — Symbols indicating the chemical structure of polyamide materials in Data Block 1

Symbol	Name and chemical structure
PA 6	Polyamide 6; homopolymer based on ϵ -caprolactam
PA 66	Polyamide 66; homopolycondensate based on hexamethylenediamine and adipic acid
PA 69	Polyamide 69; homopolycondensate based on hexamethylenediamine and azelate acid
PA 610	Polyamide 610; homopolycondensate based on hexamethylenediamine and sebacic acid
PA 612	Polyamide 612; homopolycondensate based on hexamethylenediamine and dodecanedioic acid ¹⁾
PA 11	Polyamide 11; homopolymer based on 11-aminoundecanoic acid
PA 12	Polyamide 12; homopolymer based on ω -aminododecanoic acid or on lauro lactam
PA MXD6	Polyamide MXD6; homopolycondensate based on <i>m</i> -xylenediamine and adipic acid
PA 46	Polyamide 46; homopolymer based on tetramethylenediamine and adipic acid
PA 1212	Polyamide 1212; homopolymer based on dodecanediamine and dodecanedioic acid ¹⁾

1) 1,10-Decanedicarboxylic acid.

Table 2 — Symbols indicating the chemical structure of copolyamide materials in Data Block 1 (examples)

Symbol	Chemical structure
PA 66/610	Polyamide copolymers based on hexamethylenediamine, adipic acid and sebacic acid
PA 6/12	Polyamide copolymers based on ϵ -caprolactam and lauro lactam
PA 6T/6I	Polyamide copolymers based on hexamethylenediamine, terephthalic acid and isophthalic acid
PA 6/66/PACM 5	Polyamide ternary copolymers of ϵ -caprolactam, hexamethylenediamine, adipic acid, bis(<i>p</i> -aminocyclohexyl)methane and adipic acid
PA 12I/PDI	Polyamide copolymers of lauro lactam, isophthone diamine and isophthalic acid
The following two designations include an indication of the mass content ratio:	
PA 66/6 (90/10)	Polyamide copolymers based on 90 % (m/m) hexamethylenediamine and adipic acid and 10 % (m/m) ϵ -caprolactam
PA 66/6 (20/80)	Polyamide copolymers based on 20 % (m/m) hexamethylenediamine and adipic acid and 80 % (m/m) ϵ -caprolactam

3.2 Data Block 2

In this data block, information about intended application or method of processing is given in position 1 and information about important properties, additives and colour in positions 2 to 8. The code-letters are specified in table 3.

If information is presented in positions 2 to 8 and no specific information is given in position 1, the letter X shall be inserted in position 1.

Table 3 — Codes used in Data Block 2

Code-letter	Position 1	Positions 2 to 8
A	Blow moulding	Processing stabilized
B		Antiblocking
C1		Coloured, transparent
C2		Coloured, non-transparent
D		Powder, dry blend
E		Expandable
F		Special burning characteristics
G		Pellets; granules
H		Heat-aging stabilized
K		Light and/or weather stabilized
L	Extrusion of pipes, profiles and sheets Extrusion of film and thin sheeting	Natural (not coloured)
M		Moulding release agent
N		Lubricated
R		Improved transparency
S	General use	Stabilized against hydrolysis
T		Antistatic
W	Coating	
X	Cable and wire coating	
Z	Monofilament extrusion	
	Injection moulding	
	Rotational moulding	
	Powder coating or sintering	
	Tape manufacture	
	No indication	

3.3 Data Block 3

In this data block, the viscosity number is represented by a two-figure code-number (see 3.3.1) and the tensile modulus of elasticity by a three-figure code-number (see 3.3.2). The two codes are separated from each other by a hyphen.

Nucleated polyamides may be designated by the letter N in the very last position of Data Block 3.

If a property value falls on or near a range limit, the manufacturer shall state which range will designate the material. If subsequent individual test values lie on, or either side of, the range limit because of manufacturing tolerances, the designation is not affected.

NOTE 1 Not all combinations of the values of the designatory properties are provided by currently available materials.

3.3.1 Viscosity number

The viscosity number shall be determined in accordance with ISO 307, using the solvent specified in table 4. The average value of the viscosity number is represented by a two-figure code-number as specified in table 4.

For copolyamides, 96 % (m/m) sulfuric acid should preferably be used as solvent, but some copolyamides dissolve better in *m*-cresol. Information concerning the most suitable solvent can be obtained from the supplier of copolyamides and homopolyamides which are not covered by the last column of table 4.

Table 4 — Code-numbers used for viscosity number in Data Block 3

Code-number	Range of viscosity number ml/g		Applicable to
	Solvent: 98 % (m/m) sulfuric acid	Solvent: <i>m</i> -cresol	
09	≤ 90		PA 6
10	> 90 to 110		PA 66
12	> 110 to 130		PA 69
14	> 130 to 160		PA 610
16	> 160 to 200		PA 612
22	> 200 to 240		PA MXD6
27	> 240 to 280		Copolyamides
32	> 280 to 340		
34	> 340		
11		≤ 110	PA 1212
12		> 110 to 130	PA 11
14		> 130 to 150	PA 12
16		> 150 to 170	Copolyamides
18		> 170 to 200	
22		> 200 to 240	
24		> 240	

NOTE 2 Viscosity numbers determined with 80 % (m/m) formic acid as solvent can be converted into viscosity numbers determined in 98 % (m/m) sulfuric acid using the following equations:

For PA 6

$$\ln y = 0,416 \, 1 + 0,927 \, 6 \ln x$$

For PA 66

$$\ln y = 0,454 \, 1 + 0,926 \, 1 \ln x$$

For PA 69

$$\ln y = 0,463 \, 4 + 0,909 \, 5 \ln x$$

For PA 610

$$\ln y = 0,982 \, 3 + 0,793 \, 2 \ln x$$

where

x is the viscosity number in 80 % (m/m) formic acid;

y is the viscosity number in 98 % (m/m) sulfuric acid.

For the viscosity number of PA 612, which may be determined in accordance with ISO 307 in either *m*-cresol or 98 % (m/m) sulfuric acid, the following conversion formula applies:

$$\ln y = 0,285 \, 7 + 0,985 \, 9 \ln x$$

where

x is the viscosity number in 98 % (m/m) sulfuric acid;

y is the viscosity number in *m*-cresol.

The above conversion formulae have been calculated from the results of an interlaboratory investigation carried out in 1982 (see ISO 307:1984, clause 13). The accuracy of the conversions depends on both the size of the viscosity number and the type of PA, the latter resulting from the fact that different numbers of the different PA-types were included in the investigation. The 95 % confidence intervals for the values of the nominal viscosity number in 98 % (m/m) sulfuric acid, converted from different values of the nominal viscosity number in the other solvent, are given in table 5.

Table 5 — Confidence intervals

Nominal viscosity number ¹⁾	95 % confidence intervals for converted nominal viscosity numbers in 86 % (m/m) sulfuric acid				
	PA 6	PA 66	PA 69	PA 610	PA 612
100	+0,8	±1,6	±2,0	±4,7	±4,4
140	±0,8	±1,4	±1,9	±4,1	±4,9
180	±0,7	±1,2	±2,9	±5,8	±10,2
220	±0,7	±1,3	±4,7	±9,0	±17,6
260	±0,8	±1,7	±6,9	±12,9	±26,0
300	±1,0	±2,4	±9,3	±17,2	±35,3
340	±1,3	±3,3	±11,8	±21,8	±45,3

1) Solvents: 86 % (m/m) formic acid for PA 6, PA 66, PA 69 and PA 610; *m*-cresol for PA 612.

3.3.2 Tensile modulus of elasticity

The tensile modulus of elasticity shall be determined in the dry state in accordance with ISO/R 527 under the test conditions specified in ISO 1874-2. The average value of the tensile modulus of elasticity is represented by a three-figure code-number as specified in table 6.

Table 6 — Codes used for tensile modulus of elasticity in Data Block 3

Tensile modulus of elasticity	
Code-number	Range MPa
001	≤ 150
002	> 150 to 250
003	> 250 to 350
004	> 350 to 450
005	> 450 to 600
007	> 600 to 800
010	> 800 to 1 500
020	> 1 500 to 2 500
030	> 2 500 to 3 500
040	> 3 500 to 4 500
050	> 4 500 to 5 500
060	> 5 500 to 6 500
070	> 6 500 to 7 500
080	> 7 500 to 8 500
090	> 8 500 to 9 500
100	> 9 500 to 10 500
110	> 10 500 to 11 500
120	> 11 500 to 13 000
140	> 13 000 to 15 000
160	> 15 000 to 17 000
190	> 17 000 to 20 000
220	> 20 000 to 23 000
250	> 23 000

3.4 Data Block 4

In this data block, the type of filler or reinforcing material is represented by one code-letter in position 1 and its physical form by a second code-letter in position 2 (see table 7 and ISO 1043-2). Subsequently (without a space), the mass content may be given by a two-figure code-number in positions 3 and 4.

Mixtures of materials or forms may be indicated in parentheses by combining the relevant codes using the sign "+". For example, a mixture of 25 % (m/m) glass fibre (GF) and 10 % (m/m) mineral powder (MD) would be indicated by (GF25+MD10).

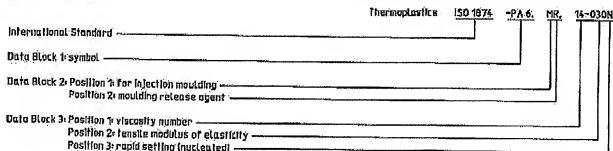
Table 7 — Coding system for fillers and reinforcing materials in Data Block 4

Code-letter	Material (Position 1)	Form (Position 2)
B	Boron	Balls; beads; spherules Powder; dry blend Fibre Granules; ground Whiskers.
C	Carbon ¹⁾	
D		
F		
G	Glass	
H		
K	Chalk (CaCO ₃)	
M	Mineral ¹⁾ ; metal ²⁾	
S	Organic; synthetic ¹⁾	
T	Talcum	
X	Not specified	Not specified
Z	Others ¹⁾	Others

1) These materials may be defined after position 4 of the data block, for example by chemical symbol or additional codes to be agreed upon.
2) Metal filler shall be identified by the chemical symbol (in capital letters) after the mass content. For example, steel whiskers may be designated "MH05FE".

4 Examples of designations

4.1 A polyamide material (PA 6) for injection moulding (M), with moulding release agent (R), having a viscosity of 150 mPa·s (14) and a tensile modulus of elasticity of 2 700 MPa (030), and with a nucleating additive (N), would be designated:



Designation: ISO 1874-PA 6,MR,14-030N

4.2 A polyamide material (PA 66) for injection moulding (M), with special burning characteristics (F) and a heat-ageing stabilizer (H), having a viscosity number of 140 ml/g (14) and a tensile modulus of elasticity of 10 200 MPa (100), and reinforced with 37 % of glass fibre (GF), would be designated.

	Thermoplastics	ISO 1874	-PA 66	MFH	14-100	GF37
International Standard						
Data Block 1: symbol						
Data Block 2: Position 1: for injection moulding						
Position 2: special burning characteristics						
Position 3: heat-ageing stabilized						
Data Block 3: Position 1: viscosity number						
Position 2: tensile modulus of elasticity						
Data Block 4: Position 1: glass						
Position 2: fibre						
Position 3: mass content range						

Designation: ISO 1874-PA 66, MFH, 14-100, GF37

4.3 A polyamide material containing plasticizer (PA 12-P), for extrusion (E), with a heat-ageing stabilizer (H) and a light and weather stabilizer (L), and having a viscosity number of 210 ml/g (22) and a tensile modulus of elasticity of 280 MPa (003), would be designated:

	Thermoplastics	ISO 1874	-PA 12-P	EHL	22-003
International Standard					
Data Block 1: symbol					
Data Block 2: Position 1: for extrusion					
Position 2: heat-ageing stabilized					
Position 3: light and/or weather stabilized					
Data Block 3: Position 1: viscosity number					
Position 2: tensile modulus of elasticity					

Designation: ISO 1874-PA 12-P, EHL, 22-003

Annex A (normative)

Definition and designation of aliphatic polyamides

Polyamide materials are thermoplastic materials that contain carboxylic amide groups, $-\text{CONH}-$, at regular intervals in the linear polymer chain.

Polyamide homopolymers may be built up from a single starting material (an aminocarboxylic acid or its lactam); in this case, they are designated by a number corresponding to the number of carbon atoms in the starting material (see table A.1).

Table A.1 — Designation of linear aliphatic polyamides of general formula $-\text{[NH}-(\text{CH}_2)_x-\text{CO}]_n-$

Symbol	Value of x	Number of C atoms in the starting material
PA 6	5	6
PA 11	10	11
PA 12	11	12

However, polyamide homopolymers may also be built up from one starting material with amino groups plus one starting material with carboxylic acid groups. These polyamides, based on diamines and dicarboxylic acids, are designated by a two-digit, three-digit or four-digit number, respectively. In the case of the four-digit number, the first digit (or the first and second digits) corresponds to the number of C atoms in the linear aliphatic diamine and the second digit (or with some materials the second and third or the third and fourth digits) corresponds to the number of C atoms in the linear aliphatic dicarboxylic acid (see table A.2).

Table A.2 — Designation of linear aliphatic polyamides of general formula $-\text{[NH}-(\text{CH}_2)_x-\text{NH-CO}-(\text{CH}_2)_y-\text{CO}]_n-$

Symbol	Value of	
	x	y
PA 66	6	4
PA 610	6	8
PA 612	6	10
PA 46	4	4
PA 1212	12	10

Copolymer polyamides, also called copolyamides, may be built up from various starting materials (lactams, aminocarboxylic acids, equimolar amounts of diamines and dicarboxylic acids). These copolyamides are designated PA plus numbers representing the components of the copolyamide, the numbers being separated by an oblique stroke (see ISO 1043-1:1987, annex A, clause A.6). But copolyamides with the same numbers or symbols can have quite different properties, depending on the ratio of the starting materials. Therefore, if there is a need for a more exact designation, the mass content ratio shall be included. If it is necessary to indicate this ratio, the two figures, separated by an oblique stroke, may be placed in parentheses at the end of the designation (see table 2).

Starting materials (monomers) for copolyamides, as well as for homopolyamides, include not only linear aliphatic compounds, but also branched aliphatic, aliphatic-aromatic, cyclo-aliphatic and aromatic compounds. The monomer units of these non-linear aliphatic compounds may be derived from the substances listed, together with their designations, in table A.3.

Because of the large number of possible combinations of copolyamides, only a few examples have been listed in table 2.

Table A.3 — Symbols of non-linear aliphatic monomer units

Symbol of monomer unit	Monomer unit derived from
T	Terephthalic acid (CAS No. 100-21-0)
I	Isophthalic acid (CAS No. 121-85-5)
N	2,6-Naphthalenedicarboxylic acid (CAS No. 1141-38-4)
PACP	2,2-Bis(p-aminocyclohexyl)propane (CAS No. 3377-24-0)
MACM	3,3'-Dimethyl-4,4'-diaminodicyclohexylmethane (CAS No. 6884-37-5)
PACM	Bis(p-aminocyclohexyl)methane (CAS No. 1781-71-3)
IPD	Isophorone diamine (CAS No. 2855-13-2)
ND	1,6-Diamino-2,2,4-trimethylhexane (CAS No. 3230-53-1)
IND	1,8-Diamino-2,4,4-trimethylhexane (CAS No. 3238-54-2)
PPGD	Polypropylene glycol diamine (CAS No. 8046-10-0)
PBGD	Polybutylene glycol diamine (CAS No. 27417-83-0)
MXD	m-Xylylene diamine (CAS No. 1477-55-0)
PTD	p-Toluylene diamine (CAS No. 95-70-5)
MTD	m-Toluylene diamine (CAS No. 95-80-7)
PABM	Diphenylmethane-4,4'-diamine (CAS No. 101-77-9)
MC	1,3-Bis(aminomethyl)cyclohexane (CAS No. 2579-20-6)
X	Not specified

NOTE — The designations ND and IND are derived from the chemical names nonyldiamine and isononyldiamine to avoid having to include numbers in the designations.

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Preface

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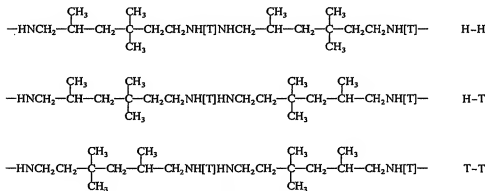
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many of the same properties led to other uses such as coatings and wire jacketing. The susceptibility to modification by adding or changing monomers was obvious because the condensation method of synthesis was simple, straightforward, classic organic synthesis, and the need and the technique to achieve high molecular mass had been demonstrated. Later studies showed how major improvements in specific properties without excessive penalty in other areas could be achieved by use of suitable additives and modifiers. This viability has been an important factor in the continued growth of nylon plastics and is discussed at length in Chap. 11. The relatively low melt viscosity and high melting point of nylon resins compared to the previously available polyacrylates, polystyrenes, and polyvinyls also opened up a new page in the processing of thermoplastics.

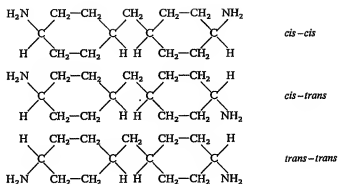
1.2 Nomenclature

The genesis of the term *nylon* has been the subject of some conjecture, but the change from "norun" (for stronger hosiery) to "niron" (to avoid sounding like a nerve tonic) to "nylon" (to avoid ambiguity in pronunciation) seems reasonable [5]. The nylons initially produced were all linear and aliphatic as indicated in Eqs. (1.1) and (1.2) and were conveniently identified by the number of carbon atoms, *x* and *y*, in the monomer(s). Where two monomers are needed as in Eq. (1.1), the number of carbon atoms in the diamine is given first. The monomers most often used in nylons, their common names, their Chemical Abstract System (CAS) names and registry numbers, their designations, and sources are listed in Table 1.1. As shown, nonlinear monomers are now used also and are almost always indicated by an abbreviation. ISO 1874-1 designations are followed except for trimethylhexamethylenediamine which, as shown, is a mixture of two isomers and requires use of the dual designations, ND and IND. Using both in a polymer, for example NDT/INDT, does identify it as a copolymer, but does not tell the whole story because of the existence of head-to-head (H-H), head-to-tail (H-T), and tail-to-tail (T-T) possibilities with either isomer. This is illustrated below for the polymer from the 2,4,4-isomer and terephthalic ([T] = —OCC₆H₄CO—):



For simplicity this book uses TMD for the isomer mixture. Some monomers have not yet been given ISO abbreviations. They will be identified as needed, as is done for 2-methylpentamethylenediamine (MPMD) in Table 1.1. Use of MPMD involves a dissymmetry similar to that of 2,2,4- or 2,4,4-trimethylhexamethylenediamine and also forms H-H, H-T, and T-T isomers. Another special case is PACM which consists of three geometric

isomers:



The properties of polymers made with PACM depend on the relative amounts of these isomers. One obviously expects copolymers to differ from homopolymers. It is important to recognize that some monomers commonly identified by a single abbreviation may involve elements of disorder that do not occur with the familiar monomers identified by a number.

Table 1.1 Monomers for Nylons

Common and [CAS] Name	No. or Symbol	Source	CAS Registry No.
Linear, Aliphatic Monomers			
Adipic acid [hexanedioic acid]	6	Benzene, toluene	124-04-9
Azelaic acid [nonanedioic acid]	9	Oleic acid	123-99-9
Sebacic acid [decanedioic acid]	10	Castor oil	111-20-6
Dodecanedioic acid [same]	12	Butadiene	693-23-2
Tetramethylenediamine [1,4-butanediamine]	4	Acrylonitrile + HCN	110-60-1
Hexamethylenediamine [1,6-hexanediamine]	6	Butadiene, propylene	124-09-4
Dodecamethylenediamine [1,12-dodecanediamine]	12	Butadiene	2783-17-7
11-Aminoundecanoic acid	11	Castor oil	2432-99-7
[undecanoic acid, 11-amino-]			
ϵ -Caprolactam [2H-azepin-2-one, hexahydro]	6	Benzene, toluene	105-60-2
Dodecanolactam or laurilactam	12	Butadiene	947-04-6
[azocyclotridecane-2-one]			
Monomers with Methyl Side Groups			
2-Methylpentamethylenediamine	MPMD ^a	Butadiene	15520-10-2
[1,5-pentanediamine, 2-methyl]			
Trimethylhexamethylenediamine	TMD ^a	Acetone	2,2,4- = ND = 3236-53-1
[mix of 1,6-hexanediamine, 2,2,4-trimethyl, and isomer]			2,4,4- = IND = 3236-54-2
Ring-containing Monomers			
Isophthalic acid [1,3-benzenedicarboxylic acid]	I	<i>m</i> -Xylene	121-91-5
Terephthalic acid [1,4-benzenedicarboxylic acid]	T	<i>p</i> -Xylene	100-21-0
bis(<i>p</i> -Aminocyclohexyl)methane	PACM	Aniline + formaldehyde	1761-71-3
[cyclohexanamine, 4,4'-methylenebis-]			
<i>m</i> -Xylylenediamine [1,3-benzenedimethanamine]	MXD	<i>m</i> -xylene	1477-55-0
<i>p</i> -Xylylenediamine [1,4-benzenedimethanamine]	PXD	<i>p</i> -xylene	539-48-0

All nos. or symbols are as in ISO 1874-1 except for ^a as used in this book; 6-3 is also used for TMD. Other, less common monomers are listed in ISO 1874-1 or Table 11.11.

It is often convenient to make from a diamine practice is to identify appropriate monodiamine and diacid the designations the discussion, the space provide a form for uses a hyphen between the ISO method those for blends are

Polycaprolactam = Poly(hexamethylenediamine) Poly(hexamethylenediamine) PA-612

Poly(*m*-xylene adipic acid) PA-MXD6

A copolymer made A copolymer made A blend of PA-6 and A blend of PA-66 and

Note that symbols of a copolymer; repeat avoids the example, the homopolymer. AAB type nylon absolute need of all moieties in the repeat. The common name [19, 20] is awkward mostly follow IUPA monomers so that (

1.3 Common

In addition to the common and their PA design have been made since as well as that of I resins are provided: diverse and large quantities designed to serve in alone, more than 10 susceptibility to moisture all producers is identified

Table 1.3 identifies countries of manufacture does not include monomers

It is often convenient to classify the nylons in Eq. (1.1) as AABB resins to show they were made from a diamine and a diacid. Similarly, the nylons in Eq. (1.2) are AB types. ISO practice is to identify a nylon by an abbreviation for polyamide followed by a space and the appropriate monomer symbol(s), e.g., PA 66. No comma or slash is used between the diamine and diacid symbols. Although the PA representation has come into common use and the designations that follow eliminate any uncertainty as to the kind of polyamide under discussion, the space after PA is often omitted in the literature. In addition, ISO does not provide a form for nylon blends. This book, therefore, departs slightly from ISO practice. It uses a hyphen between PA and the symbols to assure uniformity and, with slight alteration, uses the ISO method of representing a copolymer. Examples of the forms used here including those for blends are shown below.

Polycaprolactam = $H-[HN(CH_2)_5CO]_n-OH$ = PA-6

Poly(hexamethylene adipamide) = $H-[HN(CH_2)_6NHCO(CH_2)_4CO]_n-OH$ = PA-66

Poly(hexamethylene dodecanoamide) = $H-[HN(CH_2)_6NHCO(CH_2)_{10}CO]_n-OH$ = PA-612

Poly(*m*-xylene adipamide) = $H-[HNCH_2-m-C_6H_4CH_2NHCO(CH_2)_4CO]_n-OH$ = PA-MXD6

A copolymer made from a mixture of the monomers for 6 and 66 = PA-6/66

A copolymer made from a mixture of the monomers for 66 and 612 = PA-66/612

A copolymer made from a mixture of the monomers for 66 and MXD6 = PA-66/MXD6

A blend of PA-6 and PA-66 = PA-6/PA-66

A blend of PA-66 and PA-66/612 = PA-66/PA-66/612

Note that symbols (numbers or abbreviations) separated by a slash identify the components of a copolymer; repetition of PA- after the slash indicates a blend of polymers. Use of these forms avoids the confusion that has sometimes occurred in the literature between, for example, the homopolymer (PA-612), the copolymer (PA-6/12), and the blend (PA-6/PA-12). AABB type nylons, as well as AB types, are regarded as homopolymers because of the absolute need of alternation of both reactants to form a polymer chain that includes both moieties in the repeating structure. This is consistent with IUPAC recommendations [18]. The common names (Table 1.2) are routinely used for nylons. The IUPAC naming system [19, 20] is awkward and is rarely encountered in the commercial literature. The CAS names mostly follow IUPAC practice but, as shown, not always. Pronunciation is in accord with the monomers so that 66 is six-six not sixty-six, 612 is six-twelve, 11 is eleven, etc.

1.3 Commercial Nylon Plastics

In addition to the common and CAS names, Table 1.2 provides a list of commercial nylons, and their PA designations and CAS registry numbers. It also shows that several new nylons have been made since PA-66 and PA-6 first appeared. The history of PA-11 and PA-12 [21] as well as that of PA-66 [7] and PA-6 [12] has been reviewed. Details on the commercial resins are provided in Chap. 13. The modifications discussed in Chap. 11 have yielded a very diverse and large population of nylon compositions with specific property enhancements designed to serve individual markets. The comment [2] made in February 1989, "This year alone, more than 100 new nylon and nylon-based resins will be introduced," attests to the susceptibility to modification of nylon plastics. The total number of nylon resins offered by all producers is estimated to be about 1500.

Table 1.3 identifies major producers, the nylons they make, trade names, and the countries of manufacture. The list includes the principal nylon products of each company; it does not include modified materials because they are much too numerous. Exception is made

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CAS Registry No.

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123-99-9
111-20-6
693-23-2
110-60-1
124-09-4
2783-17-7
2432-99-7

105-60-2
947-04-6

15520-10-2

1,4-ND = 3236-53-1
4-IND = 3236-54-2

121-91-5
100-21-0
1761-71-3

1477-55-0
539-48-0

or TMD.